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(E74-10130) IDENTIFICATION OF PHENOLOGICAL STAGES AND VEGETATIVE TYPES FOR LAND USE CLASSIFICATION Bimonthly Progress Report (Alaska Univ., Palmer.) 32 p HC $3.75 CSCL 08F G3/13 N74-13057 Unclas 00130

EIGHTH BI-MONTHLY PROGRESS REPORT
UNIVERSITY OF ALASKA
ERTS PROJECT NO. 110-2
November 30, 1973

A. TITLE OF INVESTIGATION: Identification of Phenological Stages and Vegetative Types for Land Use Classification

B. PRINCIPAL INVESTIGATOR/GSFC ID: Jay D. McKendrick/UN 641

C. PROBLEMS IMPEDING INVESTIGATION:

The major problem with which we are currently concerned is the incomplete operational status of the color display unit (CDU). The unit as of this week would not display 37 scan lines either at the top or bottom of the scene, depending upon the operator's choice, and would not display picel data along the right side of the CDU scene. That data loss along the right side of the scene amounts to a strip about 4 miles wide on the earth's surface. Such voids are unacceptable in finished maps.

D. PROGRESS REPORT:

1. Accomplishments during reporting period.

All test sites have been type mapped at 1:250K and 1:63,360 scales from NASA supplied aircraft data. These overlaps serve as equal-scale ground truth comparisons for our ERTS-1 classifications.

Our first three classification results from digital tapes have been displayed on the CDU and photographed. Two CDU displays were mapped at the 1:250,000 scale and one has been mapped at the scale 1:63,360. Those classifications proved to be highly accurate and significantly better than existing maps. Vegetation classifications on the CDU were about 90% correct when compared to aircraft data mapped for those areas.

Based on these early results, cost and time estimates for mapping vegetation for all of Alaska were computed.

Computer compatible tapes for thirteen CDU scenes have been converted, and their respective ten's and unit's listings were brought from Fairbanks to Palmer for signature extraction.

The PI reported at GSFC October 26, as requested (see enclosed report copies). He, on the return trip to Alaska, also attended the American Society of Photogrammetry meeting in Sioux Falls, South Dakota (October 29 - November 1) and met with the Soil Conservation Services Cartographic Division in Portland, Oregon. The latter meeting, was scheduled as a result of requests by the SCS for comments concerning the ERTS-1 photo map of Alaska being prepared by that agency. Valuable assistance was given our Institute by the SCS group in the form of detailed requirements for the proper preparation of map manuscripts.

We have attempted to maintain close contact with the Joint Federal-State Land Use Planning Commission. That Commission is charged with broad responsibilities in matters pertaining to land use and management in Alaska. As such they are in need of data not only for the 586,400 squares of land surface, but also for the continental shelf of Alaska, which exceeds the land mass in size. Consequently they are very receptive to any assistance the University of Alaska ERTS-1 team can give them.

2. Plans for next reporting period.

We expect to complete the ERTS-1 project objectives of mapping vegetation types in the Susitna, Matanuska and Kenai test areas. These maps in conjunction with existing and contemplated Soil Conservation Service soil type maps and with what is known about the climatological conditions for those regions will be useful for selecting sites for cropland development and range units for livestock grazing. They will also be valuable to current land and resource managing agencies including the Bureau of Land Management, the Alaska State Division of Lands and local borough governments.

The phenological observations objective will be attempted by comparing seasonal signature changes in the Matanuska/Susitna test areas, even though adequate ERTS-1 coverage for all seasons is lacking due to cloud cover interferences.

Overlays are being made via the Zoom Transfer Scope from the NASA-supplied aircraft data at the scale of the ten's and unit's printout listings from the CDU compatible tapes. These will enable us to derive signatures very quickly from various scenes by permitting us to locate geographically the source areas for signatures.

E. SIGNIFICANT RESULTS:

Since we are interested in the practical application of ERTS data in solving a very real need in Alaska, our first results from digital data processing were used to estimate requirements for producing a vegetation type map of Alaska. Table 1 is a summary of those mapping cost estimates at the 1:250K scale for Alaska based on operational cost of the University of Alaska's CDU using ERTS-1 digital tapes and expected similar results from General Electric's Image 100. The Image 100 is used here merely to illustrate time and cost savings with a machine that reportedly has a shorter time frame of operation than our CDU. We have not used the Image 100, and we cannot personally verify if it is capable of the same operation effectiveness as the CDU. These comparisons are drawn from observations at the G.E. display booth at Sioux Falls, South Dakota during the ASP meeting. In Table 1 the salary costs of \$1.15/mi^2 were held constant among the four options, even though they should decline with the use of the Image 100 which has a relatively rapid user-machine interaction time due to the machine's computer capacity. The estimated operational charge of \$100/hr is assumed constant for both machines. We realize this approach is too slow to actually accomplish a vegetation type mapping project for all of Alaska. At our present staff level and with the CDU it would probably require 10 years to type map the state at the 1:250,000 scale. Current output with our CDU is slow because NASA tapes must be transformed to CDU compatible tapes via the IBM 360, then signatures are derived to produce classified tapes, again on the IBM 360, before the data are projected in a classified format. Turn around time ranges from 2 to 24 hours or more depending upon the availability of the computer, etc. When one has to wait that long to discover a signature error, the output rate is quite low.

Considering that each CDU display represents a land surface area of about 457 mi^2 and with a minimum of 25 CDU scenes per 1:250,000 quad sheet due to overlap, etc. it would require about 3950 CDU scenes to classify the data for the 158 USGS 1:250,000 topographic Series maps of Alaska. That amounts to almost \$500,000 worth of computer and CDU time in itself. Approached on a "piecemeal" basis the costs are further inflated because overlapping CDU scenes along map boundaries would have to be charged to the project costs, even though only small portions of those scenes would be needed. We strongly recommend avoiding the "piecemeal" approach to mapping all of Alaska's vegetation types not only because of the added cost but also to maintain consistency in classification among areas.

The most reasonable approach to such a dilemma would be to purchase digital data processing equipment with a short time frame for use-machine interaction with which to classify the data. That would then require increasing the size of the data transfer (map manuscript preparation) operation in order to keep up with the data classification system. Thus, the number of Zoom Transfer Scopes and operators would need to be increased. Table 2 presents estimated state-wide mapping costs for such an approach. Data processing costs include: digital data classification costs at $100/hr, $1,000 for aircraft data for each quad sheet, incidental travel expenditures within Alaska and $800 per quad sheet for publication. Salary cost estimates include one PI, one technician, four data transfer assistants and a 1/4 secretary for 24 months. The 375,000 for the Image 100 purchase is used again as an example and not an endorsement of a particular piece of equipment. We are assuming that upgrading of our CDU real-time processing capability or other brand-name products, if available, would have a comparable purchase price.

F. PUBLICATIONS:

a) In preparation - A report to be delivered to the Alaska Rural Development Council was prepared for presentation 6 December, 1973 in Anchorage:

McKendrick, Jay D. 1973, Mapping Alaskan Vegetation from ERTS-1 Data. A report to the Alaska Rural Development Council. December 6, 1973, Anchorage, Alaska (copies to be distributed to meeting participants.)

Oral presentations of our recent progress with the project including the showing of slides and product samples were given 29 November, 1973 to the Spenard and Palmer Kiwanians farm-city luncheon and to members of the resource team of the Joint Federal-State Land Use Planning Commission for Alaska in Anchorage. Two grade school groups, one Explorer post of the Boy Scouts of America, one visitor from Japan and two local Alaskan State Fish and Game personnel visited our facilities recently.

G. RECOMMENDATIONS:

From recent meetings with users and impressions received at the American Society of Photogrammetry meeting in Sioux Falls, South Dakota, it is apparent that selling ERTS requires more than quoting cost-benefit ratio statistics and showing imagery to potential users. Finished products from ERTS must sell themselves. Therefore, the quickest way to get potential data users, such as planning groups and managing agencies, to accepting ERTS data is to personally give such people samples of finished products, i.e. vegetation maps constructed from ERTS data. At the same time one should explain how quickly the data can be reduced and interpreted using automated processing equipment. This does not mean we should de-emphasize the standard route of scientific report publishing. However, most scientists now admit that relying on the printed technical paper for information transfer alone is often the slowest route in getting new findings to the ultimate user.

H. CHANGES IN STANDING ORDER FORMS: None

I. ERTS IMAGE DESCRIPTORS FORMS

Completed forms for new data is attached.

J. DATA REQUEST FORMS: None

TABLE 1. Current mapping cost estimates for four options each used to publish 2,000 copies of 1:250,000 scale vegetation maps by the Institute of Agricultural Sciences with present staff level using ERTS-1 data. (Time required to produce 158 maps = 10 years.)

Cost/Unit Area	Using Available U of A Equipment		Using GE Image 100 Systematic Approach	
	Piecemail Requests	Systematic Quad Sheet Approach	Rental	Purchase
Salary/mi^2	1.15	1.15	1.15	1.15
Equipment & Operational costs/mi^2	1.02	.85	.41	.72
Total Cost/mi^2	2.17	2.00	1.56	1.87
Total Cost for Alaska	1,272,488	1,172,800	914,784	1,096,568

TABLE 2. Current estimated costs for mapping vegetation (from ERTS data) and publishing 2,000 copies of each 1:250,000 scale USGS base map at the Institute of Agricultural Sciences if three additional ZTS and the GE Image 100 or comparable type of equipment were purchased and three more draftsmen were hired to complete the 158-map project in 24 months.

Data processing, publication costs, ground truth expenses, travel, including $100/hr to operate Image 100	248,047
Salaries and Overhead	211,200
Purchase Image 100	375,000
Supplies and Services	22,000
Three Zoom Transfer Scopes	16,200
Total cost to map Alaska	$ 872,447
Cost/mi^2	$ 1.489

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

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D ______

N ______

ID ______

DATE December 7, 1973

PRINCIPAL INVESTIGATOR Dr. J. McKendrick

GSFC UN-641

ORGANIZATION University of Alaska - 110-02

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*				DESCRIPTORS
	River	Glacier	Lake	Mts.	
1338-20555	✓				City
1341-21130	✓		✓	✓	River
1342-21182	✓		✓	✓	River
1350-20223	✓	✓		✓	Basin
1351-20275	✓	✓	✓	✓	River
1351-20282	✓	✓		✓	River
1352-20333		✓	✓		Highway
1352-20340	✓	✓	✓	✓	River
1353-20394	✓	✓	✓	✓	Highway
1358-21075	✓	✓	✓	✓	
1387-20275	✓	✓		✓	Basin
1388-20335	✓			✓	
1389-20380	✓				Basin
1389-20382	✓	✓	✓	✓	Highway
1389-20385	✓	✓	✓	✓	River

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO ERTS USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

GSFC 37-2 (7/72)

ERTS IMAGE DESCRIPTOR FORM

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ID

DATE December 7, 1973

PRINCIPAL INVESTIGATOR Dr. J. McKendrick

GSFC UN-641

ORGANIZATION University of Alaska - 110-02

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*				DESCRIPTORS
	River	Glacier	Lake	Mts.	
1389-20391	✓	✓	✓	✓	
1389-20394	✓	✓	✓	✓	
1390-20443	✓	✓	✓	✓	
1390-20450	✓	✓		✓	
1390-20452	✓		✓	✓	
1406-20331	✓	✓	✓	✓	Bay
1406-20334	✓	✓		✓	
1407-20374	✓			✓	
1407-20380	✓			✓	
1407-20385	✓	✓	✓	✓	
1408-20430	✓				
1408-20432	✓				
1408-20435	✓		✓	✓	Highway
1409-20493	✓				
1423-20264		✓	✓	✓	

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GSFC UN-641

ORGANIZATION University of Alaska - 110-02

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*				DESCRIPTORS
	River	Glacier	Lake	Mts.	
1423-20270	✓	✓	✓	✓	
1441-20264	✓	✓	✓	✓	
1441-20270	✓				

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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GSFC 37-2 (7/72)

REPORT
ERTS-1 INVESTIGATION NUMBER 110-B
UNIVERSITY OF ALASKA
INSTITUTE OF AGRICULTURAL SCIENCE

Prepared by
JAY D. McKENDRICK
26 October 1973

Since Alaska is largely undeveloped we still have an opportunity to choose courses that will avoid certain errors common in the development of other states. From the standpoint of agriculture two of the pitfalls that we must avoid are: (1) we must select for crop production only those lands best suited for such. Lands ill-suited for cropping cannot produce at levels high enough for economically sound operations. Eventually those poorer lands are abandoned. Besides being an economical drain on the farmer, such lands, when abandoned may become breeding grounds for weeds and insects and/or seriously eroded.

(2) We must also protect potentially prime agricultural lands from encroaching urbanization. To some unfamiliar with Alaska, that statement may sound inappropriate. However, even though Alaska is a very large state (586,400 sq.mi.) with a very low human population (300,000), farms are being subdivided at an alarming rate. Several factors contribute to that problem: (1) one-third of the state's population live in the Anchorage area; (2) most of Alaska's developed farms are within commuting distance from Anchorage; (3) most non-farm land is publicly owned and unavailable for private purchase. Thus, farm land market prices (and correspondingly the taxes) are inflated to levels above crop production potentials through pressure for home sites. The demands for food and housing are likely to continue upward throughout

the nation. However, the present shortsightedness that is causing the waste of potentially prime agricultural land will be regretted in the future. As a publicly supported agricultural research group, we of this institute believe our responsibility is to enlighten the public to this threat on a most critical basis resource. Presumably, those so enlightened will consciously choose land development plans that protect the undeveloped as well as developed lands from irreparable damages of misuse by agriculture as well as by urbanization. Alaskan land resources remain largely uninventories; therefore, acquiring basic land resource information has a high priority among Alaskan planners.

Since native vegetation is an indicator of environmental conditions, maps of native vegetation communities are very useful in evaluating land resources. We believe ERTS data are the best available for mapping native vegetation of areas such as Alaska, which are too vast to be mapped economically with conventional methods.

Thus, the objectives in our ERTS-1 project were: (1) to attempt to identify and map native vegetation and (2) to document vegetation's phenological changes through observing the "green wave."

I am leaving a sample of some of our mapping products to illustrate what a potential user group might do with ERTS data. These maps were prepared by one of our technicians and an assistant. Our technician is a former Soil Conservation Service employee who has had about 1.5 years field experience with that agency. The assistant has had no formal training in remote sensing. I mention these facts to emphasize the point that these maps were prepared by people with backgrounds typical of many potential ERTS user groups.

SUMMARY OUTLINE
ERTS INVESTIGATION NUMBER 110-B
UNIVERSITY OF ALASKA
INSTITUTE OF AGRICULTURAL SCIENCES
OCTOBER 26, 1973

I. Scientific Results

A. Identification and measurement capabilities

Visual recognitions on black and white prints and transparencies

1. Certain natural vegetation boundaries can be seen:

   a. Separation of coniferous from deciduous forest

   b. Separation of coniferous from grassland

   c. Separation of coniferous from tundra

2. Rivers, mountains, bodies of water are easily recognized

3. Clouds

   Heavy clouds with distinct borders are better than wispy or hazy conditions.

4. Identification of clearings

   Certain highways and fields depending upon the type of natural vegetation bordering the road systems etc. can be identified. Roads and railroads cutting through forests can be seen. Roads constructed by the oil companies on the tundra at Prudhoe Bay are recognizable on 9.5 inch prints.

   Densitometric processes (VP-8)

   Cloud shadows can be separated from water in band 5 and they are not distinguishable in band 7. Silty water can be distinguished from clear water.

   Color additive processes:

   -The most powerful effect of this tool is separating areas with vegetation cover from those without. The black and white data cannot be interpreted accurately in that aspect.

   -Certain vegetation patterns become more easily recognized, e.g. muskeg are more easily separated from coniferous forests.

   -Silty water is distinguishable from clear water.

Digital data

These data are the most powerful we have found for delineating vegetation community boundaries. We have had excellent results identifying stands of coniferous forest, deciduous forest, and bodies of water. Signatures for types that are variable such as brush lands, and wetlands (muskegs) are not as easily delineated because their radiometric signatures overlap. Our approach to this problem will be to examine temporally separated digital data in hope that seasonal changes will clarify the boundaries of the problem types. The data and equipment needed for examining this problem have become available only recently. However, even if certain types cannot be identified, they may be omitted on maps without detracting from the other data.

B. Interpretation techniques

Our most successful approach for image interpretation has been to delineate features readily distinguishable on ERTS data and then try to identify those patterns by using ground truth data. This approach has not always been used because there is a strong tendency to look for known ground truth patterns on the ERTS data first. There is nothing wrong with the latter approach as long as the investigators find what they look for, but when they cannot find the sought after patterns, there is a tendency to downgrade the value of ERTS rather than to accept it for its positive values. It is generally true that we see what we look for, so the latter approach must be followed in training observers to use ERTS data.

The digital interpretation technique that has been most successful is the basic inductive reasoning process, i.e. known pure stands (from aircraft data) are located and their radiometric MSS signatures are derived. Such signatures are then applied to the general area to locate similar stands or communities. The availability of the hardware for such processes (CDU) has only become available to us recently due to delays in manufacturing.

C. Modeling

D. Usefulness of Data

The data for delineating vegetation patterns is useful, apparently quite accurate for certain types, and the most valuable data to our project because of its synoptic and repetitive nature. The repetitive coverage has not been good enough in the southcentral Alaskan region for phenological or "green wave" observations. Possibly, that phenomen could be observed better in the interior region where cloud cover for certain locations interferes relatively less than in the southcentral region.

II. Applications already achieved

A. There are two major achievements in terms of mapping.

1. Produced 1:250K vegetation maps that are significantly more accurate than previously mapped areas.

2. Tested the applicability of digital and visual processes for vegetation mapping and concluded that a combination of all available techniques is better than relying on only one method.

B. Potential applications to local programs

1. The use of ERTS data is the only practical method for providing the critically needed vegetation maps for Alaska within a reasonable time-frame and program cost. There are 158, 1:250K quad sheets for the state of Alaska. That area (assuming ideal conditions) would need approximately 130,000 air photos (1:40,000 scale). Depending upon positioning of the images the same data could theoretically be acquired on 5,000 or less CDU display scenes. A rough cost estimate would be about $1.25/mi^2$ to produce a vegetation map by using ERTS data and the digital approach. It is within our practical grasp to undertake a statewide mapping program. If the costs are distributed among local, state, and federal user groups we can probably produce the 1:250K, 1:500K and 1:1,000,000 vegetation maps in a reasonable time-frame.

C. Potential applications to federal programs

The largest federal users will likely be the land management agencies (USDA & USDI). The military (U.S. Army and Air Force) would also use such data. The Naval Petroleum Reserve #4 includes an area almost twice the size of the state of Maryland. Surely they have certain obligations of stewardship for the vegetation resource of that region. However EPA could use such products in assessing environmental hazards thay may be anticipated from various developmental programs in Alaska.

D. Work needed to develop applications

The largest single effort should concentrate on the digital data processing. There are certain problems with these data that must be solved to improve the general usefulness of the data. (1) Digital picel data represent on-the-ground areas ca. 188 ft x 260 ft. Since that area is longer than it is wide, commonly available electronic displays (TV screens) geometrically distort the image. This necessitates stretching images in order to overlay them onto base maps. This can be accomplished with the Zoom Transfer Scope. (2) Geometrically accurate displays can be produced, but that requires a considerable amount of computer time (which is expensive and/or unavailable to field-station personnel of potential user agencies).

III. Suitability of ERTS data

A. The overall suitability of the data is good.

1. Scale - OK

2. Resolution - OK

3. Radiometry

   We have problems separating some vegetation types. I am sure that given enough MSS bands some of those problems could be overcome. However, the practical costs of such efforts must be considered too. If more data are collected, data processing costs soar upward.

4. Frequency

   A 7-day cycle would be better for phenological measurements. However, due to the cloud problems we have encountered the 7-day cycle would just generate a larger storage supply of cloud-filled images in many areas of Alaska during the June-July period.

5. Format

   Not being a computer programmer, I may be speaking out of turn, but I believe a simpler digital data format might make that data more accessable to users. For instance, in their present format NASA tapes must be converted via computer to CDU compatible tapes for display and analysis. That conversion requires a computer with a relatively large storage capacity.

   Would it be practical to release NASA tapes in a format more easily adapted to display devices?

6. Timeliness

   With respect to society's stage of technological development--anything less than ERTS would be grossly short-sighted; therefore, historically ERTS is quite timely.

B. Use of A/C data (quantity)

A short flight line (10-20 miles) ERTS scene of CIR data will usually suffice for test areas, providing it is located to include representative types. Signatures should be derived or at least checked on each ERTS scene unless there is a rare day when we get clear coverage for several scenes. Actually several 2-3 frame photos from different locations are more likely to assist signature derivations than a single flight line confined to a single vegetation type.

C. Ground truth

The more one knows about an area, the more data can be derived from an ERTS scene. However, that knowledge need not be for more than a small portion of the scene, since extrapolation over distance appears to be an acceptable method when tempered with judgement.

TABLE 1. A comparison of mapping accuracies among the existing vegetation map (unpublished) prepared by Spetzman, visual mapping from bands 5 and 7 and digital mapping using bands 4, 5, 6 and 7 on the CDU at the University of Alaska. (A portion of scene 1049-20505, 10 Sept. 1972, mapped digitally at 1:250,000 on the Anchorage quadrangle and data from scene 1390-20450, 17 Aug. 1973, mapped visually.)

Flight Line No.	Existing Vegetation Map by Spetzman	ERTS Data Visually Mapped from Bands 5 & 7	ERTS Digital Data from CDU Display
4	63	83	100
5	62	79	84
	Avg. 62.5	81	92%

MAPPING ALASKAN VEGETATION FROM ERTS-1 DATA

A Report to the Alaska Rural Development Council

By: Jay D. McKendrick
Institute of Agricultural Sciences

December 6, 1973

Source of Project Support

Goddard Space Flight Center Contract No. NAS 5-21833

University of Alaska
ERTS-1 Project 110-02

A multidisciplinary team at the University of Alaska has been involved in a remote sensing research program utilizing ERTS-1 data since July 1972. The program includes twelve projects (Table 1) which received NASA data and financial support. A brief overview of project 2 is included in this report. Findings indicate that remote sensing from satellite platforms can be used to map broad classes of Alaskan vegetation quite accurately. The significance of these findings are (1) the mapping can be accomplished at a reasonable per-acre cost and (2) there is relative rapidity with which results from such data can become available to the user public compared to conventional aircraft data.

The purpose of this report is: (1) to inform the various agencies and groups represented by the ARDC on the successful applications of ERTS-1 data with respect to the vegetation resources; (2) to inform the council on future plans for furthering such work and (3) to elicit from the council a recommendation that local, state and federal governing bodies and private industry be encouraged to jointly support a project to develop and publish vegetation maps at 1:250,000 scale for the state of Alaska.

PROGRESS

Two major reasons why ERTS data have such favorable cost benefit ratios and relatively rapid availability to the user are: (1) the synoptic view of ERTS includes vast areas per scene and (2) the multispectral digital data formats are in a form suitable for computer processing.

To illustrate the synoptic view of ERTS, one frame of ERTS imagery includes an area 115 x 115 miles compared to a conventional 9 inch (1:40,000 scale) aircraft data frame of 5.6 x 5.6 miles. Considering the 60% overlap usually required in aircraft data, one ERTS frame is equivalent to about 2,640 stereo pairs of aircraft images. Obviously the savings in handling and storage costs substantially favor the space-acquired data. The trade-off for such reductions is somewhat lower resolution on the ERTS imagery. Minimal resolution on ERTS is about 300 feet on the ground. That represents a distance of 56/1,000 inch (1.4 mm) on a 1:63,360 (inch = mile) base map or 14/1,000 inch (.36 mm) on a 1:250,000 scale map. In other words for those two map scales the resolution trade-off is practically insignificant.

We have been able to identify single picture cell (picel) units (equivalent to 1 acre) stands of birch trees within a matrix of spruce or vice versa. However the practical mapping limits are on the order of 20 acres or more at the 1:63,360 scale. At that scale, 20 acres represents a square about 18/100 inch. If the Alaskan land mass was mapped on a single sheet at the 1:63,360 scale, dimensions of the map would be about 150 x 103 ft.

During the 1.5 years that ERTS-1 has been orbiting, useable cloud-free data have been acquired for all but a few localities in Alaska. Those data can be interpreted and the vegetation classified by using either the University of Alaska's IBM 360 and Color Display Unit or other machine processing equipment now available such as General Electric's Image 100.

NASA releases data in various formats. The combined use of imagery and digital tapes is the most promising approach to data analysis. The tapes and imagery for each scene are available to certain ERTS-1 investigators without charge. Others may obtain the tapes from the ERTS Data Center at Sioux Falls, South Dakota at a cost of \$140/ERTS scene and imagery for less than \$10/frame. The University of Alaska ERTS library is acquiring all useable tapes for Alaskan scenes in addition to all imagery. These are stored in the C. T. Elvey Building on campus.

We have been using such data in our current ERTS project, and have found experimental interpretation and transfer cost range from about \$1.50 to \$2.17 per mi^2 (scale 1:250,000). That includes map manuscript construction, final drafting and publication costs. Such color coded thematic maps would include major vegetation types similar to those of the Federal-State Land Use Planning Ecosystem map, i.e. coniferous forest, deciduous forest, mixed forest, brushlands, grasslands, tundra and treeless bogs, etc. The validity of our classification results was checked against aircraft data, and it compared quite well, about 90% accurate for test areas in the Matanuska/Susitna valleys and near Eagle River. The best maps available for those areas were also checked and found to be about 60% accurate with respect to those same vegetation classes.

Once data are classified they may be presented in various scales ranging from 1:63,360 to 1:1,000,000 for the cost of drafting and data transfer. That feature enhances the value of ERTS data because of the multiplicity of options available to user groups.

Basically our interpretation and classification of ERTS digital tapes involves extracting the digital signatures (the spectral "finger print") of selected vegetation types from several portions of an ERTS scene. That information is given to Dr. Robert Porter of the University of Alaska Geophysical Institute, who programs the University of Alaska's

IBM 360 computer to produce a "classified" tape. The classified tape, about 1/40 of an ERTS scene, is displayed as a color coded image on a television monitor. The image is then photographed. Classification boundaries are traced on acetate overlay of a base map from the photograph with the aid of a Bausch & Lomb Zoom Transfer Scope. The entire process involves the close cooperation of specialists from several disciplines.

Quite frankly, I have seen no better cooperation among multidisciplinary remote sensing teams than we have here in Alaska. After attending remote sensing meetings I have concluded that we in Alaska have a fine team of specialists spanning several disciplines valuable to developing and managing Alaska's natural resources. We at the University of Alaska are in a unique position because of our delayed entree into the remote sensing field. We are now able to take advantage of advances of remote sensing technology and still remain as specialists within chosen disciplines. Had our team members become involved heavily with remote sensing research earlier in their careers, it would have no doubt cost some of their chosen discipline expertise.

Currently the University of Alaska has submitted a second multidisciplinary proposal (ERTS-B or ERTS-A follow-on) to NASA for continued support for the application of ERTS data in Alaska. The Institute of Agricultural Sciences' proposal was originally designed to include four test areas: McGrath, Kodiak, Ft. Yukon and Delta Junction areas. Our objective was to map the vegetation of those areas at 1:250,000. Such maps combined with SCS soils data and climatic data would assist in identifying localities suitable for future cropland development and livestock grazing. In addition those vegetation maps could be useful to land management agencies, i.e. BLM, BIA, USFS, boroughs, the State Division of Lands, etc.

That proposal was written almost a year ago and was based on very preliminary results. Since then we have firmed up our mapping procedure, acquired data processing equipment and begun mapping areas. Those experiences indicate that the promise of ERTS exceeded our original expectations. We now believe with the existing data and current state-of-the-art, we should broaden our ERTS-B proposal's scope to include other Alaskan localities, especially those lands currently in public focus. In addition to our four original test areas, localities with high priorities should be mapped with the program continuing until the entire state is mapped at 1:250,000. Maps at 1:63,360 could be constructed in special interest areas.

There is no question but what this work will eventually be done either by the University of Alaska ERTS team or some other remote sensing group because the data and techniques are available and the maps are needed.

We have calculated the mapping costs of each of four options available to the Institute of Agricultural Sciences' ERTS group, assuming we were going to map the vegetation types for all of Alaska at 1:250,000 (Table 2). Since costs of producing such maps would be similar regardless of who does the work, the important points to note are: (1) the "piecemeal" approach is most costly, (2) our time-frame is 10 years at current staff and equipment levels, and (3) the least expensive approach may be to rent the GE Image 100. Points not apparent in the data are: (1) the Image 100 purchase option includes not only the cost of the GE Image 100 but also the $100/hr operational charge which would actually revolve within the

University if we owned the machine. In addition the Image 100 system would be available for projects other than this one, besides being available to the State after the project is completed.

If the 10-year time frame is unacceptable the work might be accomplished in about 24 months providing: (1) the Image 100 was available either at Palmer or Fairbanks and (2) three additional Zoom Transfer Scopes and operators were added to the team for the 24 month period. In Table 3 cost estimates are outlined for the purchase option and the 24 month time frame. That is the approach currently favored at the Institute of Agricultural Sciences because it appears to be not only the least expensive per acre but also the most practical considering the time requirement.

TABLE 1. Listing of the twelve University of Alaska ERTS-1 projects.

1. Coordination and Establishment of Centralized Facilities and Services for the University of Alaska ERTS Survey of the Alaskan Environment, Albert E. Belon, Geophysical Institute.

2. Identification of Phenological Stages and Vegetation Types for Land Use Classification in a Wilderness Area Subject to Imminent Development, C. I. Branton/ Jay D. McKendrick, Institute of Agricultural Sciences.

3. Identification, Definition and Mapping of Terrestrial Ecosystems in Interior Alaska, J. H. Anderson, Institute of Arctic Biology.

4. Survey of the Seasonal Snow Cover of Alaska, G. E. Weller, Geophysical Institute.

5. Breakup Characteristics of the Chena River Basin, R. F. Carlson, Institute of Water Resources; Gerd Wendler, Geophysical Institute.

6. The Study of the Caribou Movements and Winter Dispersal in Relation to Prevailing Snow Cover, P. C. Lent, Cooperative Wildlife Research.

7. Sea Ice and Surface Water Circulation in Selected Areas of the Alaskan Continental Shelf, F. F. Wright, Institute of Marine Science; J. J. Burns, Alaska Department of Fish and Game.

8. The Circulation of Prince William Sound, R. D. Muench, Institute of Marine Science.

9. ERTS Data as a Teaching and Research Tool in the Department of Geology, D. Grybeck, Department of Geology.

10. An Evaluation of the Feasibility of Mapping Seismically Active Faults in Alaska, L. D. Gedney, Geophysical Institute.

11. Glaciological and Volcanological Studies in the Wrangell Mountains, Alaska, C. S. Benson, Geophysical Institute.

12. Feasibility Study for Locating Archaeological Village Sites by Satellite Remote Sensing, W. J. Stringer, Geophysical Institute; J. P. Cook, Department of Anthropology.

TABLE 3. Current estimated costs for mapping vegetation (from ERTS data) and publishing 2,000 copies of each 1:250,000 scale USGS base map at the IAS if three additional ZTS and the GE Image 100 were purchased and three more draftsmen were hired to complete the 158-map project in 24 months.

Data processing, publication costs, ground truth expenses, travel, including \$100/hr to operate Image 100	248,047
Salaries and Overhead	211,200
Purchase Image 100	375,000
Supplies and Services	22,000
Three Zoom Transfer Scopes	16,200
Total cost to map Alaska	\$ 872,447
Cost/mi^2	\$ 1.489

TABLE ~~8~~ 7. Current mapping cost estimates for four options each used to publish 2,000 copies of 1:250,000 scale vegetation maps by the Institute of Agricultural Sciences with present staff level using ERTS-1 data. (Time required to produce 158 maps = 10 years.)

Cost/Unit Area	Using Available U of A Equipment		Using GE Image 100 Systematic Approach	
	Piecemeal Requests	Systematic Quad Sheet Approach	Rental	Purchase
Salary/mi^2	1.15	1.15	1.15	1.15
Equipment & Operational costs/mi^2	1.02	.85	.41	.72
Total Cost/mi^2	2.17	2.00	1.56	1.87
Total Cost for Alaska	1,272,488	1,172,800	914,784	1,096,568

QUESTIONNAIRE INSTRUCTIONS

The purpose of this questionnaire is to survey the basic needs for vegetation maps by organizations responsible for managing, developing, planning and utilizing Alaska's land resources. The information will be used to determine vegetation mapping research and produce priorities for the University of Alaska's ERTS program.

Please respond to all questions appropriate to you and/or your organization. Indicate N/A to questions that are not applicable.

Please return questionnaire either to Sig Restad or Jay D. McKendrick, Institute of Agricultural Sciences, Box AE, Palmer, Alaska 99645 by December 12.

QUESTIONNAIRE

1. Name of organization represented________________________________

   ____

2. Representative's name________________________________

3. Are vegetation maps used by your organization?__________________
   If yes, please indicate mapping scale(s) most useful (e.g. 1" = 1 mile or if scales are not known please estimate:__________________

   ____

4. Which vegetation map(s) is your organization now using to accomplish planning and/or management goals? (e.g. Sigafoo's, Spetzman's, etc.)

   ____

5. Are those maps adequate for your organization's needs?__________

6. Which geographical region in Alaska is most important to your organization? (e.g. Chugach National Forest, North Star Borough, Anchorage Quadrangle, etc.)________________________________

7. If 1:250,000 scale vegetation maps were available would either you or your organization acquire such maps for planning__________, management__________and/or general information__________purposes? (Please check appropriate blanks.)

8. If a project were initiated to produce vegetation maps such as these being experimentally produced by the University of Alaska's Institute of Agricultural Sciences from ERTS-1 data, please indicate how your organization could best assist such a project.

   (a)__________User group. A user group is any group that will use the finished product (map) to accomplish specific management and/or planning goals. User groups could assist the mapping project by supplying data for cost/benefit analysis and indicate need for project products.

(b)__________Participant. A participant is any group that can actively contribute toward the mapping operation by providing financial and/or "in kind" participation. ("in kind" might be providing the mapping team access to existing aircraft data, map printing, manuscript redrafting, ground truth information, etc.

(c)__________Interested organization. An interested organization is any group with interest in seeing the vegetation of Alaska mapped because they believe the data are not only valuable but also necessary for developing and implementing land management (use) plans in the state. These groups could assist by encouraging local, state and federal participation in such a project.

9. Please list below other groups in Alaska not represented on the Alaska Rural Development Council, that use and/or need vegetation maps.

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EIGHTH BI-MONTHLY PROGRESS REPORT
UNIVERSITY OF ALASKA
ERTS PROJECT NO. 110-2
November 30, 1973

PRINCIPAL INVESTIGATOR: Jay D. McKendrick

TITLE OF INVESTIGATION: Identification of Phenological Stages and Vegetative Types for Land Use Classification

DISCIPLINE: Agriculture/Forestry/Range Resources

SUBDISCIPLINE: Range Survey and Classification

SUMMARY OF SIGNIFICANT RESULTS:

Classification of digital data for mapping Alaskan vegetation has been compared to ground truth data and found to have accuracies as high as 90%. These classifications are broad scale types as are currently being used on the Major Ecosystems of Alaska map prepared by the Joint Federal-State Land Use Planning Commission for Alaska. Cost estimates for several options using the ERTS-1 digital data to map the Alaskan land mass at the 1:250,000 scale ranged between \$2.17 to \$1.49 per square mile.